Environmental Research Journal
MEDWELL PUBLICATIONS SINCE 2000

The Role of Renewable Energy on CO_2 Pollutant Reduction

Anahita Golestani Dariani, Soheila Khoshnevis Yazdi and Mohammad Khezri
Departments of Economics College of Law, Political Science and Economics Islamic Azad University, South Tehran Branch, Tehran, Iran

Key words: CO_2 emissions, economic growth, renewable energy consumption, ARDL, Iran

Corresponding Author:
Anahita Golestani Dariani
Departments of Economics College of Law, Political Science and Economics Islamic Azad University, South Tehran Branch, Tehran, Iran

Page No.: 98-107
Volume: 13, Issue 4, 2019
ISSN: 1994-5396
Environmental Research Journal

Abstract: This study examines the causal relationship between the renewable energy consumption and carbon dioxide emissions in the Iran for the period 1970-2013 using gross domestic product, gross fixed capital formation and total population. We apply Dickey-Fuller test, Johansen cointegration, Vector Error Correction Method of distribution (VECM) and Granger causality test. The findings indicate that the renewable energy consumption is significantly and negatively in the long-run. The total population is significant and positive sign and negative in the long-run and short-run, respectively. Since, the GDP coefficient is negative and GDP^2 coefficient is positive, Kuznets curve isconcave upward and U-shaped. Results show a unidirectional causality from CO_2 to GDP. Also,there isbidirectional causality between CO_2 and renewable energy consumption. Therefore, the renewable energy resourcescan help policymakers in making decisions to reduce the carbon dioxide emissions and improve the environment effectively.

INTRODUCTION

Major part of the energy supply comes from conventional non-renewable sources such as coal, oil and natural gas. As a result, there is a sharp increase in carbon dioxide (CO_2) emission in the atmosphere which considersto the main source of Greenhouse Gas (GHG) effect that led to environmental degradation. Thus, the climate change intimidation and the increasing threat of global warming rise worldwide concerns and impose serious social and political pressure to curb emissions (IEA, 2011).

This growing interest has supported by various government incentive policies such as feed-in tariff, subsidies for renewable technologies, tax rebate and so, on. Human activities involving the combustion of fossil fuels and the burning of biomass produce GHGs that affect the composition of the atmosphere and the global climate.

In Iran in order to increase the share of renewable energy, the share of ten percent of the electricity production capacity in 20 year-old document, dedicated to Renewable Energy. To increase the share of renewable energy sources in the supply of electrical energy and reduce the natural gas consumption and petroleum in power production, the Energy Department is required to plan for renewable energy sources, to provide, ten percent of the electrical energy produced by renewable sources in ten years, at least.

Raising concerns about energy security and global warming issues suggest that in the future there will be greater reliance on renewable energy sources (Wind,

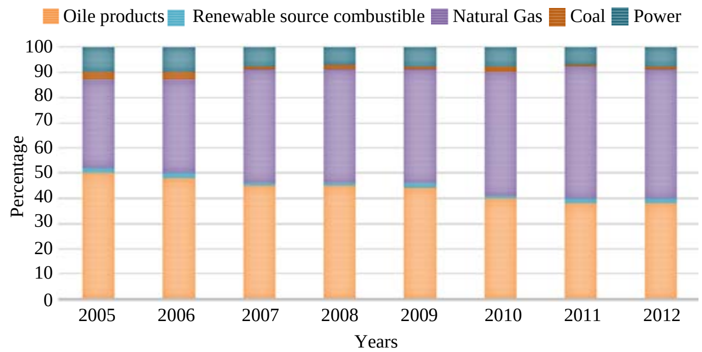

Fig. 1: The share of energy in marginal consumption, energy balance sheet (2012)

Solar, Geothermal, Hydroelectric, Biomass, Wave and Tidal). In addition, rising energy prices in the background, take attention to further exploration of renewable energy as an alternative to petrol the fossil. So, academics and craftsmen from around the world to search and strive to achieve a sustainable energy system, implementation of unlimited renewable energy that is driving the future of the world, have started.

In this case, product the percentage of electricity energy by renewable energy in Iran, the preservation of national resources, prevent of environmental pollution caused by fossil fuel combustion, employment and development of remote are as and to promote Iran's position in the strategic environment international, considered to access to sustainable energy and sustainable development.

Figure 1 shows that Petroleum products have the highest share in final consumption and then the natural gas, electricity, coal and combustible renewables contributed in final consumption in 2005 and 2006. The share of petroleum products has Equal with the share of natural gas in final consumption and jointly have the highest share in final consumption, followed by electricity, coal and combustible renewables contributed in final consumption in 2007 and 2008.

In 2009, natural gas has the highest share in final consumption and then the petroleum, power, combustible renewables and coal contributed in final consumption. In 2010, natural gas has the highest share in final consumption and then the petroleum, power, coal and combustible renewables contributed in final consumption. In 2011 and 2012, natural gas has the highest share in final consumption and then the petroleum, power, combustible renewables and coal contributed in final consumption.

In addition, expansion in service industries which is the result of economic development, can increase energy demand and so leads to pollutant emissions. Therefore, the aim of this article is to examine the relationship between renewable energy consumption, CO_2 emission, gross fixed capital formation, total population and gross domestic production for Iran for the period of 1970-2013 using Auto Regressive Distributed Lag approach (ARDL). It has generally been realized that the renewable energy consumption play a vital role for economy and environment.

Renewable energy consumption and CO_2 emissions: The relationships between economic growth and pollutant emissions and between economic growth and energy consumption, in addition combination of these two nexus in a single framework, have been investigated extensively. However, limited research has conducted on the nexus between renewable energy sources, economic growth and pollutant emissions.

Apergis etc showed that nuclear energy consumption reduces CO_2 emissions whereas renewable energy consumption does not contribute to reductions in emission in the G7 countries. These authors not that the latter result may due to the limited proportion of renewable energy in total energy consumption.

In the OECD countries, Menyah and Wolde-Rufael (2010) found that although there was no causality from renewable energy consumption to CO_2 emissions, there was unidirectional causality from CO_2 emissions to renewable energy consumption over the period from 1960 to 2007. Salim and Rafiq (2012) investigated the relationship between CO_2 emissions and renewable energy consumption, controlling for income and oil prices. The long run results obtained using the dynamic OLS and fully modified OLS methods show that CO_2 and income are the major determinants of renewable energy consumption in Brazil, China, India and Indonesia. For these countries, a bidirectional causal relationship is also found between renewable energy consumption and CO_2 emissions in the short run. The results also indicate that a bidirectional relationship between income and CO_2 emissions in Brazil, China and Turkey.

Using the Toda-Yamamoto procedure over the period from 1949-2009 for the US, Payne (2012) reveals that real

GDP and CO_2 emissions do not have causal effects on renewable energy consumption. However, unexpected shocks to real GDP and CO_2 emissions positively affect renewable energy consumption over time.

Khoshnevis studied the potential of Renewable Energy Consumption (REC) in decreasing the impact of carbon emission in Iran. Using the Environmental Kuznets Curve (EKC) hypothesis, this study analyses the impact of electricity generated using RES on the environment and trade openness for the period from 1975-2011, using the Autoregressive Distributed Lag (ARDL) approach. Results of unit root tests show that all variables are non-stationary in their level form and stationary in first difference form. The cointegration analysis shows that there is evidence of cointegration among the test variables. Granger causality tests represent a unidirectional causality running from the square of per capita GDP to per capita CO_2 emissions and renewable energy. The renewable energy consumption and economic growth has a positive bidirectional causality and contribution on emissions in the short-run.

Bloch *et al*. (2015) examined the relationship between Chinese aggregate production and consumption of three main energy commodities: coal, oil and renewable energy. Both Autoregressive Distributed Lag (ARDL) and Vector Error Correction Modeling (VECM) show that Chinese growth is led by all three energy sources. Economic growth also causes coal, oil and renewables consumption, but with negative own-price effects for coal and oil and a strong possibility of fuel substitution through positive cross-price effects. The results further show coal consumption causing pollution while renewable energy consumption reduces emissions.

Jebli and Youssef (2015) used the Autoregressive Distributed Lag (ARDL) bounds testing approach for cointegration with structural breaks and the Vector Error Correction Model (VECM) Granger causality approach to investigate relationships between per capita CO_2 emissions, GDP, renewable and non-renewable energy consumption and international trade (exports or imports) for Tunisia during the period from 1980-2009. The result shows the existence of a short-run unidirectional causality running from trade, GDP, CO_2 emission and non-renewable energy to renewable energy. Long-run estimates show that non-renewable energy and trade have a positive impact on CO_2 emissions, whereas renewable energy impacts weakly and negatively CO_2 emission when using the model with exports and this impact is statistically insignificant when using the model with imports. The inverted U-shaped Environmental Kuznets Curve (EKC) hypothesis is not supported graphically and analytically in the long-run. This means that Tunisia has not yet reached the required level of per capita GDP to get an inverted U-shaped EKC.

Policy for renewable energy: Energy policy is a strategy employed by governments to discuss issues such as generation, distribution and consumption, as well as environmental and social impacts. There are many types of policies implemented by different countries to assist and guarantee the growth of renewable energy including Feed-In-Tariff, Renewable Portfolio Standards, direct subsidies, grants, trading systems, rebates, pricing laws, tax exemptions, quota requirements and energy production credits or incentives. The primary goal of these methods is to decrease dependence on fossil fuels and their destructive environmental effects (Lipp, 2007, Dincer, 2011).

The Feed-In-Tariff (FIT) and Renewable Portfolio Standard (RPS) approaches seem to be the most popular. FIT exists at least in 61 countries around the world (Saidur *et al*., 2010). In FIT, a granted fee pays for the generation of power from renewable resources (typically for each unit of electricity production over a fixed time, e.g., 20 years); this results in a risk reduction for investors in long-term new technologies (Southworth *et al*., 2011). Likewise, an RPS is a regulation which promotes energy production (employed in 18 countries); RPS is sometimes referred to as a Renewable Electricity Standard (RES) (Saidur *et al*., 2010).

Increasing the share of RPS will promote competition for the renewable energy market as well as lead to lower prices for renewable energy (Valentine, 2011). The success of the policy relies not only on policy selection but also on policy planning, implementation and transparent, stable framework conditions. Thus, countries must select from different policies to find those that are the most adaptive with their targets, technical abilities and culture; therefore, there is no optimal worldwide method; governments must continually improve and reform policies. Sweden has been the most successful in achieving targets; they were able to surpass their 2020 targets by 2010. Figure 2 illustrates the renewable energy percentage of final energy consumption between 2005 and 2009 and targets for 2020 in selected pioneer European countries (Martinot, 2005).

The first steps,renewable resources in1994 and since that time, attention to this subject has significantly increased among authorities and society. To better clarify the issue, the fourth development program proposed that 500 MW (without considering hydro power) should be supplied from renewable resources (1% of total energy consumption), witha private sector share of 270 MW (Najafi and Ghobadian, 2011). In a 20-year Iranian development outlook, this share should reach 10% by 2025 in Iran (Fadai *et al*., 2011).

Renewable energy in developing countries: In many developing countries there is a larger potential for renewables like wind and solar energy than in

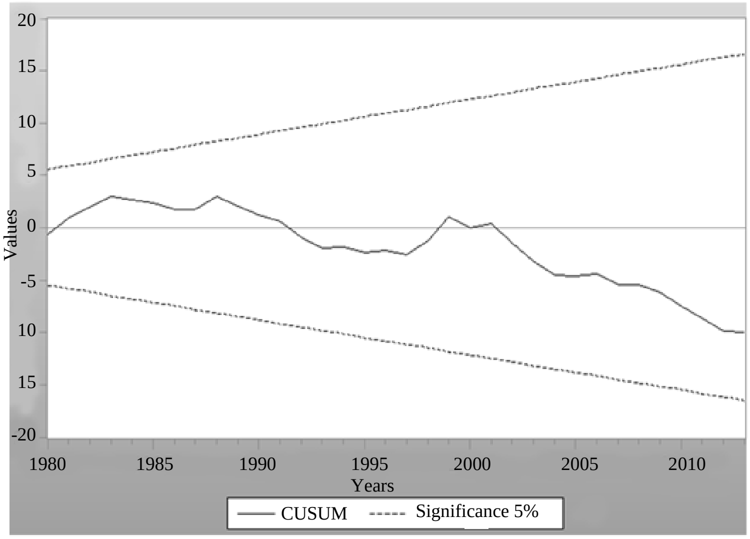

Fig. 2: Plot of cumulative sum of recursive residuals

industrialized countries. But there are obstacles that prevent such “new” renewables adoption in developing countries. However, when looking at the global scale, over 85% of the energy production from “new” renewable energy takes place in the industrialized countries.

Obstacles in the context can defined as factors that prevent or make difficult the diffusion of renewable energy technologies.There is differentiating between technological, financial, cognitive and institutional obstacles. Technological obstacles are such obstacles that relateeither to geographic and meteorological conditions which determine the renewable energy potential of a region, or to the renewable energy technology itself. Most developing countries endow with a large potential for renewable energy (Laumanns and Reiche, 2004).

Financial obstacles are the most important factor hindering renewable energydiffusion in developing countries. First of all, many renewable energy technologies are not yet competitive on a cost-basis with conventional forms of energy. In many cases, the advantage of conventional energy is still increased by subsidies. On the other hand, renewable energy systems and their components are often subject to import duties or other taxes. Secondly, the high initial cost for purchasing a renewable energy system is a major obstacle. In most developing countries, only the richest households, if at all, can afford these systems. Credit schemes that could facilitate the purchase of renewable energy technologies are still largely underdeveloped (Laumanns and Reiche, 2004).

Finally, there are also important institutional obstacles for renewable energy in developing countries. Here, we use a broad definition of institutions that encompasses both the legal framework as much as the relevant organizations and markets in the energy sector. For example, markets for renewable energy systems are generally underdeveloped in developing countries. There are only a few market actors which often suffer from a lack of capital. Secondly, there are few organizations in the developing world that explicitly promote renewable energy through information dissemination or lobbying, both on the non-governmental and the governmental level. Thirdly, legal frameworks and energy policies can represent an important obstacle to renewable energy. In developing countries, there is little direct government support for renewable energy, due to the lack of financial resources. In general, the place of renewable energy in national energy policy is often rather unclear which prevents private companies from investing in renewable energy projects (Laumanns and Reiche, 2004). Table 1 shows summary of Obstacles conditions for renewable energy in developing countries.

In principle, a success condition can define as the absence of an obstacle. Success conditions can sometimes be created through adequate government policy measures or through social learning processes. As in the case of obstacles, we can also differentiate between technological, financial, cognitive and institutional success conditions. Technological success conditions are generally difficult to create through human intervention. For example, the insolation ratio or the wind regime is factors that cannot be changed through government policy. Nevertheless, the technological potential of renewable energies in developing countries is very high. Another technological success condition is the technical

Table 1: Obstacles for Renewable Energy in Developing Countries

Technological	Cognitive	Financial	Institutional
Lack of renewable energy lobby/strong lobby for fossil energy	Low awareness for (or prejudice against) renewable energy	High initial costs of renewable energy systems	Lack of renewable energy potential
Energy policies that favor fossil energy	Negative (or little) experiences with renewable energy	Subsidies for fossil energy	Poor quality of systems
Monopolies on power production	Lack of skilled renewable energy technicians	High import duties/taxes for renewable energy	Technology not adapted to socio-cultural background
Unclear legal guidelines for energy production from renewable energy	Lack of data on renewable energy potential		Obsolete and in stable power grids
Complicated procedures for obtaining licenses			High population density
Lack of capital among renewable energy companies			
High transaction costs for sale of renewable energy systems			
Political/economic instability			

Table 2: Success conditions for renewable energy in developing countries

Institutional	Cognitive	Financial	Technological
Strong renewable energy lobby/weak lobby for fossil energy	Awareness and positive attitude towards renewable energy	Credit schemes or direct financial assistance for renewable energy	High potential for renewable energy
Preference for renewable energy in national energy policy	Positive and extensive experiences with renewable energy	Low subsidies/high taxes for fossil energy	Technical and quality standards for renewable energy
Energy sector open for IPPs	Availability of skilled renewable energy technicians	Low import duties/taxes for renewable energy	Appropriate technology
Clear legal guidelines for energy production from renewable energy	Sufficient data on renewable energy potential		Modernized and stable power grids
Uncomplicated licensing procedures			Low population density and dispersed settlement structure
renewable energy companies with adequate capacities			
Political/economic stability			

Energy for All 2004

and quality standards for renewable energy technologies that can fix either by governments or by the private sector (Laumanns and Reiche, 2004). Table 2 shows summary of success conditions for renewable energy in developing countries.

MATERIALS AND METHODS

Data description: This study uses annual time series data for Iran from 1970-2013. The period was chosen based on the availability for all the data series. Real GDP per capita (GDP) in constant 2005 US$, CO_2 emissions (CO_2) in metric tons per capita, Renewable Energy Consumption (REC) is proxies by the combustible renewables and waste (% of total energy). Gross fixed capital formation (% of GDP) and POP is total population.All data are from the World Development Indicators (WDI, 2014) online database. All the variables transformed to natural logarithms for the purpose of the analysis. We use Eviews 9 to conduct the analysis.

Model specification: To examine the long run relationship between CO_2 emissions, renewable energyconsumption, economic growth, gross fixed capital formation and total population in a linear logarithmic quadratic form with a view of testing the Environmental Kuznets Curve (EKC) hypothesis using the following Eq. 1:

$$CO_2 = f\left(GDP,\ GDP^2,\ K,\ Pop,\ REC\right) \quad (1)$$

The structure of model based on ARDL approach and it estimatedaccording to paper "Non-renewable and renewable energy consumption and CO_2 emissions in OECD countries". In order to find the long run relationship between CO_2 emissions, renewable energy consumption, economic growth, gross fixed capital formation and total population, the following linear logarithmic form is proposed:

$$\begin{aligned} \text{Ln}\ CO_{21} = {} & \alpha_0 + \alpha_1 \text{LnGDP}_1 + \alpha_2 \text{LnGDP}_1^2 + \\ & \alpha_3 \text{LnK}_1 + \alpha_4 \text{LnPOP}_1 + \alpha_5 \text{LnREC}_1 + \varepsilon_1 \end{aligned} \quad (2)$$

Based on the environmental Kuznets curve hypothesis, the multivariate framework is established to investigate the long-run relationship between per capita carbon dioxide (CO_2), per capita real GDP (GDP), squared of per capita real GDP (GDP^2), Renewable Energy Consumption (REC), gross fixed capital formation and total population.

As regards the EKC hypothesis, we advance three separate panels to examine the estimated causality of the short and long-run links where emission of CO_2 is the dependent variable. Based on EKC hypothesis, the sign and value of a_1 and a_2 indicate different functional forms. When $a_1 = a_2 = 0$, this indicates a level relationship when $a_1<0$ and $a_2 = 0$, this indicates a monotonically decreasing linear relationship, when $a_1>0$ and $a_2 = 0$, this indicates a monotonically increasing linear relationship when $a_1<0$ and $a_2>0$, this represents U-shaped relationship and when $a_1>0$ and $a_2<0$, this indicates an inverted U-shaped relationship, hence the EKC.

In this article, CO_2 emissions in response to per capita GDP growth shocks, a reaction similar to U of shows, So CO_2 emissions shows the reduction reaction at first and then increase. Gross fixed capital formationcould be a factor leading to decrease of CO_2 emissions; a_3 is expected negative.

Also according, Hang and Yuan-Sheng (2011) concluded that there is a positive association between total population and CO_2 emissions, thus $a_4>0$. Since, renewable energy could be a factor leading to decrease of CO_2 emissions, a_5 is expected negative. We expect that with renewable energy, the sign is negative if the level of energy used is high enough and the industrial sectors use the clean technology for production but it could be positive if the level of renewable energy is rather low and the technology used for production is polluting.

Econometric methods

Ardl bounds testing of cointegration: The Autoregressive Distributed Lag (ARDL) approach suggested by Pesaran *et al*. (2001) is applicable for variables that are I(0) or I(1) orfractionally integrated. The analysis begins byinvestigating the unit root test of variables using the augmented dickey and Fuller,1981 ADF and Philips and Perron,1988 PP tests. In both tests the null hypothesis of the series has a unit root is experienced against the alternative of stationary. The ARDL framework of Eq. 3 of the model isas follows:

$$\Delta \text{Ln } CO_{21} = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta \text{Ln}CO_{21\text{-}i} + \sum_{i=1}^{n} \alpha_{2i} \Delta \text{LnGDP}_{t\text{-}i} + \sum_{i=1}^{n} \alpha_{3i} \Delta \text{LnGDP}^2_{t\text{-}i} + \sum_{i=1}^{n} \alpha_{4i} \Delta \text{LnK}_{t\text{-}i} + \sum_{i=1}^{n} \alpha_{5i} \Delta \text{Ln POP}_{t\text{-}i} + \sum_{i=1}^{n} \alpha 6i \Delta \text{LnREC}_{t\text{-}i} + \lambda \text{ECM}_{t\text{-}i} + u_t \quad (3)$$

a_0 and e_t is the drift component and white noise, respectively. a_1-a_5 denote the error correction dynamics while a_1-a_6 correspond to the long-run relationship in baseline Eq. 2. Where ECM_{t-1} is the error correction term which is gained from the following estimated cointegration Eq. 4:

$$\text{ECM}_t = \text{Ln}CO_{2t}\text{-}a_0 \sum_{i=1}^{n} \alpha_{1i} \Delta \text{Ln}CO_{2t\text{-}i} + \sum_{i=1}^{n} a_{2i} \Delta \text{LnGDP}_{t\text{-}i} + \sum_{i=1}^{n} a_{3i} \Delta \text{LnGDP}^2_{t\text{-}i} + \sum_{i=1}^{n} a_{4i} \Delta \text{LnK}_{t\text{-}i} + \sum_{i=1}^{n} a_{5i} \Delta \text{Ln POP}_{t\text{-}i} + \sum_{i=1}^{n} a_{6i} \Delta \text{LnREC}_{t\text{-}i} \quad (4)$$

In the ARDL bounds testing approach the first step is to estimate Equation 3 by Ordinary Least Square (OLS).The critical values of the F-statistics in this test present by Pesaran and Pesaran, 1997. The Error Correction Term (ECM_{t-1}) indicates the speed of the adjustment and shows how quickly the variables return to the long-run equilibrium and it should have a statistically significant coefficient with a negative sign. To ensure the suitability of model, the diagnostic and stability tests are also conducted. These include, testing for serial correlation, functional form, normality and heteroscedasticity associated with selected models. Pesaran *et al*. (2001) suggested approximately the stability of long and short-run estimate through Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ).

Thus the stability tests such as CUSUM and CUSUMSQ are conducted in order to check the stability of coefficient in estimated model.

Granger causality: The cointegration approaches are employed to test the existence or absence of long-run relationship between variables. To test the direction of causality between carbon dioxide emissions, economic growth, renewable energy consumption,gross fixed capital formation and total population. The Granger approach based on the Vector Error Correction Model (VECM) is employed.The test answers the whether X causes Yor Y causes X. X is said to be Granger caused by Y ify helps in the prediction of the present value of x orequivalently if the coefficients on the lagged y's arestatistically significant. There is a long-runrelationship between variables in the model, thelagged Error Correction Term (ECM_{t-1}) isobtained from the long-run cointegration relationship and was included in the equation as an additional independent variable. The following model is used to test the causal relationship between the variables Eq. 3:

$$\begin{bmatrix} \Delta LnCO_{2t} \\ \Delta LnPGDP_t \\ \Delta LnPGDP_t^2 \\ \Delta LnK_t \\ \Delta LnPOP_t \\ \Delta LnREC_t \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ c_5 \\ c_6 \\ c_7 \end{bmatrix} + \sum_{i=1}^{p} \begin{bmatrix} \beta_{11i} & \beta_{12i} & \beta_{13i} & \beta_{14i} & \beta_{15i} & \beta_{16i} \\ \beta_{21i} & \beta_{22i} & \beta_{23i} & \beta_{24i} & \beta_{25i} & \beta_{26i} \\ \beta_{31i} & \beta_{32i} & \beta_{33i} & \beta_{34i} & \beta_{35i} & \beta_{36i} \\ \beta_{41i} & \beta_{42i} & \beta_{43i} & \beta_{44i} & \beta_{45i} & \beta_{46i} \\ \beta_{51i} & \beta_{52i} & \beta_{53i} & \beta_{54i} & \beta_{55i} & \beta_{56i} \\ \beta_{61i} & \beta_{62i} & \beta_{63i} & \beta_{64i} & \beta_{65i} & \beta_{66i} \\ \beta_{71i} & \beta_{72i} & \beta_{73i} & \beta_{74i} & \beta_{75i} & \beta_{76i} \end{bmatrix} \begin{bmatrix} \Delta LnCO_{2t} \\ \Delta LnPGDP_t \\ \Delta LnPGDP_t^2 \\ \Delta LnK_t \\ \Delta LnPOP_t \\ \Delta LnREC_t \end{bmatrix} + \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \\ \lambda_7 \end{bmatrix} ECM_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \\ \varepsilon_{7t} \end{bmatrix} \quad (5)$$

ECT_{t-1} is the lagged error-correction term. Residual terms are uncorrelated random disturbance term with zero mean and j's are parameters to be estimated. The direction of causality can be detected through the VECM of long-run cointegration. The VECM captures both the short-run and the long-run relationships. The long-run causal relationship can established through the significance of the lagged ECTs in equations based on test and the short-run Granger causality is detected through the test of significance of F-statistics of Wald test of the relevant j coefficients on the first difference series.

RESULTS AND DISCUSSION

Results and descriptive statistics: Annual data for CO_2 emissions (CO_2) (metric tons per capita), per capita real GDP (GDP) in constant 2005 US is as the proxy of economic growth, Renewable Energy Consumption (REC) is proxies by the combustible renewable and waste (% of total energy), Gross fixed capital formation (% GDP) and total Population (POP). The sample period is for 1970-2013 based on the annual times series data availability.

We have used the ADF unit root test to check for stationary. The results in Table 3 indicate that all variables are non-stationary at their level form and stationary at their first differences.

Carbon dioxide emissions(CO_2), economic growth (GDP), Renewable Energy Consumption (REC), gross fixed capital formation (K) and total Population (POP) are stationary over the period 1970-2013 in Iran.

ARDL (2, 0, 0, 0, 1, 0) represents the ARDL model in which the CO_2 emissions and total population take the lag length 2, 1, respectively. As can be seen from Table 4, 5 there is 3 cointegrating vectors in long run, so there is cointegrating relationship among variables in long-run. The long-run estimates describes in Table 6.

The coefficient of GDP is negative and coefficient of GDP2 is positive, so, environmental Kuznets curve is Concave upward and u-shaped. As a result, CO_2 emissions in response to per capita GDP growth shocks, So, CO_2 emissions shows the reduction reaction at first and then increase. This result is consistent with Stavins (2009) studies.

The coefficient on Renewable Energy Consumption (REC) shows a negative and significant impact on CO_2 emissions the long run estimated coefficient related to renewable energy consumption show that, a 1% increase in renewable energy consumption in the same conditions, decrease CO_2 emissions by 0.10%. This result is similar to the findings of Jebli and Youssef (2015).

Also the coefficient on gross fixed capital formation (K) shows a negative and significant impact on CO_2 emissions in Iran. So, a 1% increase in K in the same

Table 3: Augmented dickey-fuller stationary test results

Variable	Constant No trend	Critical values	Variables	Constant No. trend	Critical value
Ln CO_2	-0.557435	-2.931404	ΔLn CO_2	-4.763266	-2.935001*
Ln GDP	-1.903327	-2.933158	Δ Ln GDP	-3.597648	-2.933158*
Ln GDP^2	-1.898987	-2.933158	ΔLn GDP^2	-3.589633	-2.933158*
Ln K	-3.213293	-2.931404	Δ Ln K	-7.088890	-2.938987*
Ln POP	0.105133	-1.950687	Δ Ln POP	-1.762787	-1.611059**
Ln REC	-1.687040	-2.931404	ΔLn REC	-6.750007	-2.933158*

*Denotes for 5% significance level, ** Denotes for 10% significance level, Estimation using Eviews 9

Table 4: Unrestricted cointegration rank test (trace)

Hypothesized No. of CE(s)	Eigen values	Trace statistic	Critical value (0.05)	Prob**
None*	0.821398	165.873600	95.753660	(0.0000)
At most 1*	0.655382	93.524620	69.818890	(0.0002)
At most 2*	0.465499	48.781270	47.856130	(0.0408)
At most 3	0.243239	22.471530	29.797070	(0.2730)
At most 4	0.153424	10.765810	15.494710	(0.2263)
At most 5	0.085862	3.770508	3.841466	(0.0522)

Trace test indicates 3 cointegration eqn(s) at the 0.05 level, *denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values

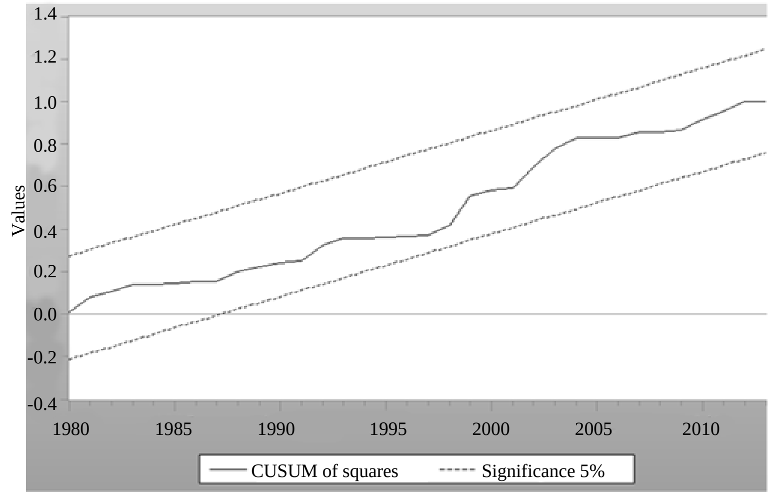

Fig. 3: Plot of cumulative sum of squares of recursive residuals

Table 5: Unrestricted cointegration rank test (maximum eigenvalue)

Hypothesized No. of CE(s)	Eigen value	Max-eigen statistic	Critical value (0.05)	Prob**
None*	0.821398	72.349020	40.07757	(0.0000)
At most 1*	0.655382	44.743340	33.87687	(0.0017)
At most 2	0.465499	26.309750	27.58434	(0.0721)
At most 3	0.243239	11.705720	21.13162	(0.5769)
At most 4	0.153424	6.995299	14.26460	(0.4897)
At most 5	0.085862	3.770508	30.841466	(0.0522)

Max-eigenvalue test indicates 2 cointegration eqn(s) at the 0.05 level, *denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values

Table 6: Long-run estimation results

Variables	Coefficient	SE	T-tatistic	Prob
Ln GDP	-1.46**	0.464300	-3.1423	(0.003)
Ln GDP^2	0.14**	0.031061	4.9783	(0.000)
Ln K	-0.22**	0.091918	-2.5255	(0.016)
Ln Pop	0.23**	0.091962	2.6338	(0.012)
Ln REC	-0.10**	0.036217	-3.0431	(0.004)

**significant at 5% level, calculation using Eviews 9

Table 7: Error correction model (ECM) for short-run elasticity ARDL (2,0,0,0,1,0)

Variable	Coefficient	SE	T-statistic	Prob
dLn CO2	0.28**	0.116190	2.4519	(0.019)
dLn GDP	-1.19**	0.434960	-2.7312	(0.009)
dLn GDP2	0.13*	0.033082	3.8058	(0.000)
dLn K	-0.19*	0.075796	-2.4938	(0.017)
dLn Pop	-5.31*	1.585900	-3.3533	(0.002)
dLn REC	-0.09	0.032776	-2.7380	(0.009)
ECM(-1)	-0.81	0.120030	-6.7839	(0.000)
R-Squared	0.61280			
Durbin-watson	1.7483			

**significant at 5% level, Author's calculation using Eviews 9

conditions will lead to about 0.22% decrease in per capita CO_2 emissions in the long-run. According to Table 7, the Error Correction Mechanism (ECM) is used to check the short-run relationship among the variables. The error correction term is statistically significant and its magnitude is quite higher indicates a faster return to equilibrium in the case of disequilibrium. This term shows the speed of adjustment process to restore the equilibrium. The relatively high coefficients imply a faster adjustment process. The values of the coefficients of ECM_{t-1} (-0.81) indicating that the variables will adjust to the long run equilibrium in about 1.2 period following a short-run shocks.

The Coefficient for the renewable energy consumption is not significant in the short-run. This result is similar to the findings of Rufael etc. Whereas obtained coefficients for other variables are significant in the short-run. The coefficient of gross fixed capital formation (K) is negative and significant, thus with 1% change K in the same conditions will lead to 0.19% decreases in the per capita CO_2 emissions. Furthermore the coefficient of total population is negative and significant, so with a 1% change POP in the same conditions, will lead to 5.32% decreases in the per capita CO_2 emissions.

Further, renewable energy consumption was obtained negative and significant in long run, but there was not significant in short run. Also total population is positive and significant in long- run and is negative and significant in short- run.

The model was also tested for stability of the short-run and long-run coefficients by testing the CUSUM and CUSUMSQ tests. Figure 2 and 3 illustrate that the coefficients stability are supported because the plots of

Table 8: Granger causality results

Variables	Short-run dLnCO2	dLnGDP	dLnK	dLnPOP	dLnREC	Long-run ECM(-1)
dLnCO2	-	7.4592**	6.2188**	11.2445**	7.4966**	46.0207**
	-	[0.006]	[0.013]	[0.001]	[0.006]	[0.000]
dLnGDP	0.62546	-	1.9910	0.074139	0.022961	0.083077
	[0.429]	-	[0.158]	[0.785]	[0.880]	[0.773]
dLnK	8.1114**	13.9718**	-	0.081652	6.4647**	28.5351**
	[0.004]	[0.001]		[0.775]	[0.011]	[0.000]
dLnPop	1.8515	5.0266***	0.0012934	-	0.26853	1.1841
	[0.174]	[0.081]	[0.971]	-	[0.604]	[0.277]
dLnREC	4.4269 **	0.2350E-4	1.3208	0.070832	-	10.0415**
	[0.035]	[0.996]	[0.250]	[0.790]	-	[0.002]

X→Y means X Granger causes Y, ** and *** denote the statistical significance at the 5% and 10% levels, respectively, Author's calculation using Eviews 9

both CUSUM and CUSUMSQ fall within the critical bounds of 5% significance. The straight lines represent critical bounds at 5% significance level. The straight lines represent critical bounds at 5% significance level. We apply CUSUM and CUSUMSQ (Brown *et al*., 1975). The CUSUM test basically uses the cumulative sum of recursive residuals based the first set of n observations and is updated recursively and then plotted against the break points. If the CUSUM plot remains within the critical bounds at 5% significance level (represented by clear and straight lines drawn at 5%, the null hypothesis that all the coefficients and the error correction model are stable, cannot be rejected (Table 8).

The Granger causality test shows in Table 8, the funding Indicates abidirectional causal relationship between gross fixed capital formation and CO_2 emissions, also there is a bidirectional relationship between renewable energy consumption and CO_2 emissions.

The here is a unidirectional relationship from CO_2 emissions to GDP. There is also a unidirectional causal relationship from CO_2 emissions to total population. There is no causal relationship between GDP and renewable energy consumption.It is obvious that economic growth will not affected by renewable energy consumption.

CONCLUSION

In this study, we investigate the long and short-run relation between carbon dioxideemissions, economic growth, renewable energyconsumption, gross fixed capital formation and total populationusing Autoregressive Distributed Lag (ARDL) approach and Granger causality. We test the EKC hypothesis is over the period1970-2013 using cointegration techniques.

The long-run estimates support the U-shapedcurve of EKC hypothesis between per capita GDP and CO_2 emissions. The interesting result deduced from the long-run estimates suggests that, the coefficient of renewable energy consumption isnegative and statistically significant in long run, while it is not statistically significant in short run. It explains that increase renewable energy consumption will decrease CO_2 emissions in long-run. Additionally, the impacts of gross fixed capital formation variables are negative and statistically significant in both of short and long- run. It explains thatan increase in the gross fixed capital formation will decrease CO_2 emissions.Also, the coefficient of GDP GDP^2 is negative and positive, respectively. Further, impact of total population on CO_2 emissions ispositive and statistically significant in long-run.

The results of Granger causality test show that there is a bidirectional causal relationship between gross fixed capital formation and CO_2 emissions, renewable energy consumption and CO_2 emissions, there is also a unidirectional causal relationship from CO_2 emissions to total population.

CO_2 emissions decrease with economic growth thenreach a turning point and then start to increase withhigher level of economic growth.The results imply the importance consumption of renewableenergy in controlling CO_2 emissions in long run in Iran. Given to all the positive impacts of renewable energy sources oneconomic and environment have been slow government efforts and investment in developmentof renewable sources consumption.

Iran is one of the regions that have a high potential in the use of renewable resources and with such a large supply of energy can produced considerable amount of electrical energy easily. Despite the hot and dry weather, especially in the central areas of Iran and high levels of sunshine and wind in most regions show high potential for solar and wind energy in Iran. As an offer, governments should design effective support policies to promote investment in renewable energy technologies.

REFERENCES

Bloch, H., S. Rafiq and R. Salim, 2015. Economic growth with coal, oil and renewable energy consumption in China: Prospects for fuel substitution. Econ. Model., 44: 104-115.

Dickey, D.A. and W.A. Fuller, 1981. Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49: 1057-1072.

Dincer, F., 2011. The analysis on wind energy electricity generation status, potential and policies in the world. Renewable Sustainable Energy Rev., 15: 5135-5142.

Fadai, D., Z.S. Esfandabadi and A. Abbasi, 2011. Analyzing the causes of non-development of renewable energy-related industries in Iran. Renewable Sustainable Energy Rev., 15: 2690-2695.

Hang, G. and J. Yuan-Sheng, 2011. The relationship between CO2 emissions, economic scale, technology, income and population in China. Procedia Environ. Sci., 11: 1183-1188.

IEA., 2011. Energy balances of OECD countries. International Energy Agency (IEA), Paris.

Jebli, M.B. and S.B. Youssef, 2015. The environmental Kuznets curve, economic growth, renewable and non-renewable energy and trade in Tunisia. Renewable Sustainable Energy Rev., 47: 173-185.

Laumanns, U. and D. Reiche, 2004. Energy for all: Obstacles and success conditions for RE in developing countries. Refocus, 5: 18-20.

Lipp, J., 2007. Lessons for effective renewable electricity policy from Denmark, Germany and the United Kingdom. Energy Policy, 35: 5481-5495.

Menyah, K. and Y. Wolde-Rufael, 2010. CO2 emissions, nuclear energy, renewable energy and economic growth in the US. Energy Policy, 38: 2911-2915.

Najafi, G. and B. Ghobadian, 2011. LLK1694-wind energy resources and development in Iran. Renewable Sustainable Energy Rev., 15: 2719-2728.

Payne, J.E., 2012. The causal dynamics between US renewable energy consumption, output, emissions and oil prices. Energy Sour. Part B: Econ. Plann. Policy, 7: 323-330.

Pesaran, M.H. and B. Pesaran, 1997. Working with Micro Fit 4.0: Interactive Econometric Analysis. Oxford University Press, Oxford, England, Pages: 505.

Pesaran, M.H., Y. Shin and R.J. Smith, 2001. Bounds testing approaches to the analysis of level relationships. J. Applied Econ., 16: 289-326.

Phillips, P.C.B. and P. Perron, 1988. Testing for a unit root in time series regression. Biometrika, 75: 335-346.

Saidur, R., M.R Islam, N.A. Rahim and K.H, Solangi, 2010. A review on global wind energy policy. Renewable Sustainable Energy Rev., 14: 1744-1762.

Salim, R.A. and S. Rafiq, 2012. Why do some emerging economies proactively accelerate the adoption of renewable energy?. Energy Econ., 34: 1051-1057.

Valentine, S.V., 2011. Japanese wind energy development policy: Grand plan or group think?. Energy Policy, 39: 6842-6854.